

2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review

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NextEnergy Microgrid and Hydrogen Fueling Facility



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NextEnergy

Objectives - 0



- To support the DOE “Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project” in the Detroit area
- To collect and analyze data with existing codes and standards and establish a “Best Practices” training and educational program

Objectives - I



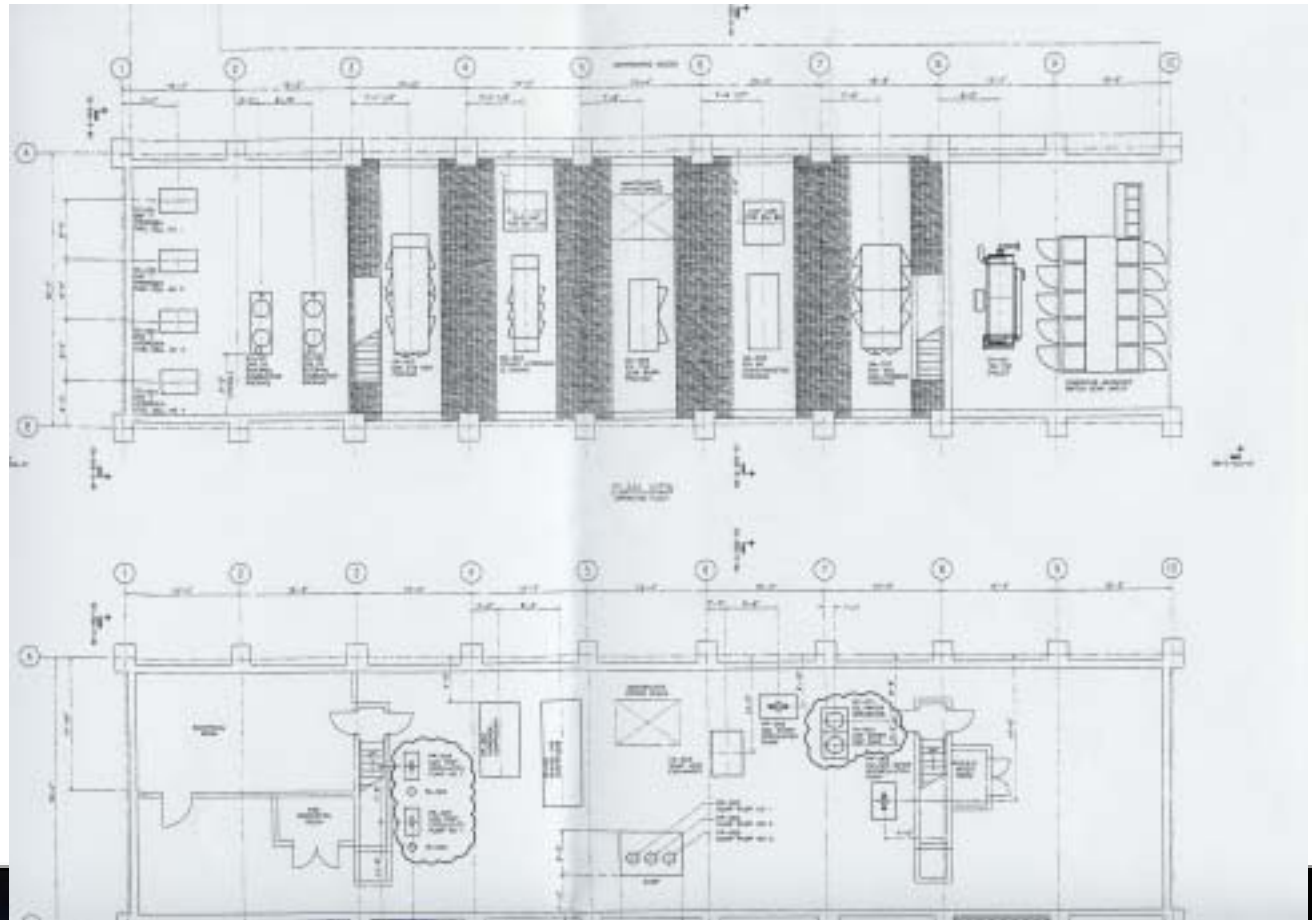
- To integrate, within a core urban environment, critical hydrogen infrastructure components and systems for multi-use operations
- To optimize SYSTEM solutions/integration to advance the hydrogen infrastructure for vehicular and stationary use

Objectives - II

- To provide hydrogen to vehicles at 3,600 psig and 5,000 psig (for demos in the Detroit area)
- To study the system interactions/integration for power generation (~ 1 MW) in a Microgrid with fuel cells, ICE generators, Stirling engines, and solar PV

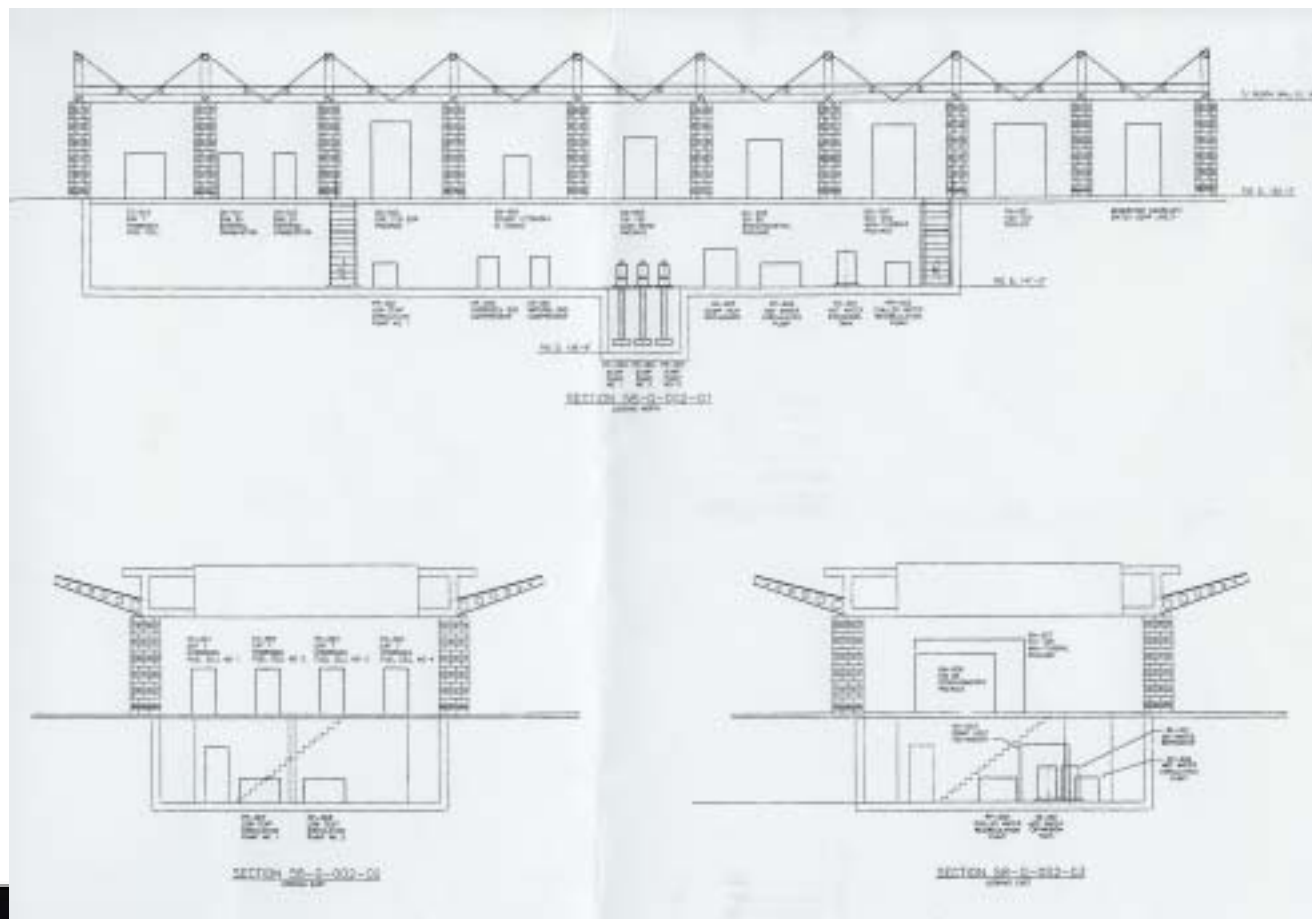
Blueprint: Plan Layout for Power Generation Systems (Hydrogen and Natural Gas) in the Microgrid

(Note: in the actual poster session, the blueprints will be larger in size)



Blueprint: Vertical View of the Microgrid Power Sources (Hydrogen and Natural Gas)

(Note: in the actual poster session, the blueprints will be larger in size)



Microgrid Components

| | |
|--|----------------|
| 4-Plug Power Fuel Cells (H2) | 20 kW |
| 2-STM Stirling (H2 & NG) | 104 kW |
| 1-Menag EGR IC engine | 210 kW |
| 1-DTE Turbine | 355 kW |
| 2-DTE IC Engine (iPower) | 225 kW |
| 1-Ford/Stuart H2 IC engine | 120 kW |
| PV Array (Unisolar) | 30 kW |
| Total | 1064 kW |
| Thermal recovery systems (Heating/Chilling) | |
| Underground electrical | |
| Underground thermal | |
| Flex. foundation/interconnects | |

Budget

- Total NextEnergy Center Project
(powered by Hydrogen, Natural Gas,
Other Fuels): \$ 22.0 million

THIS PROGRAM ONLY:

- NextEnergy Microgrid and Hydrogen
Fueling Facility: \$ 4.54 million
 - NextEnergy share: \$ 2.54 million
 - DOE share: \$ 2.00 million

SITE DRAWING



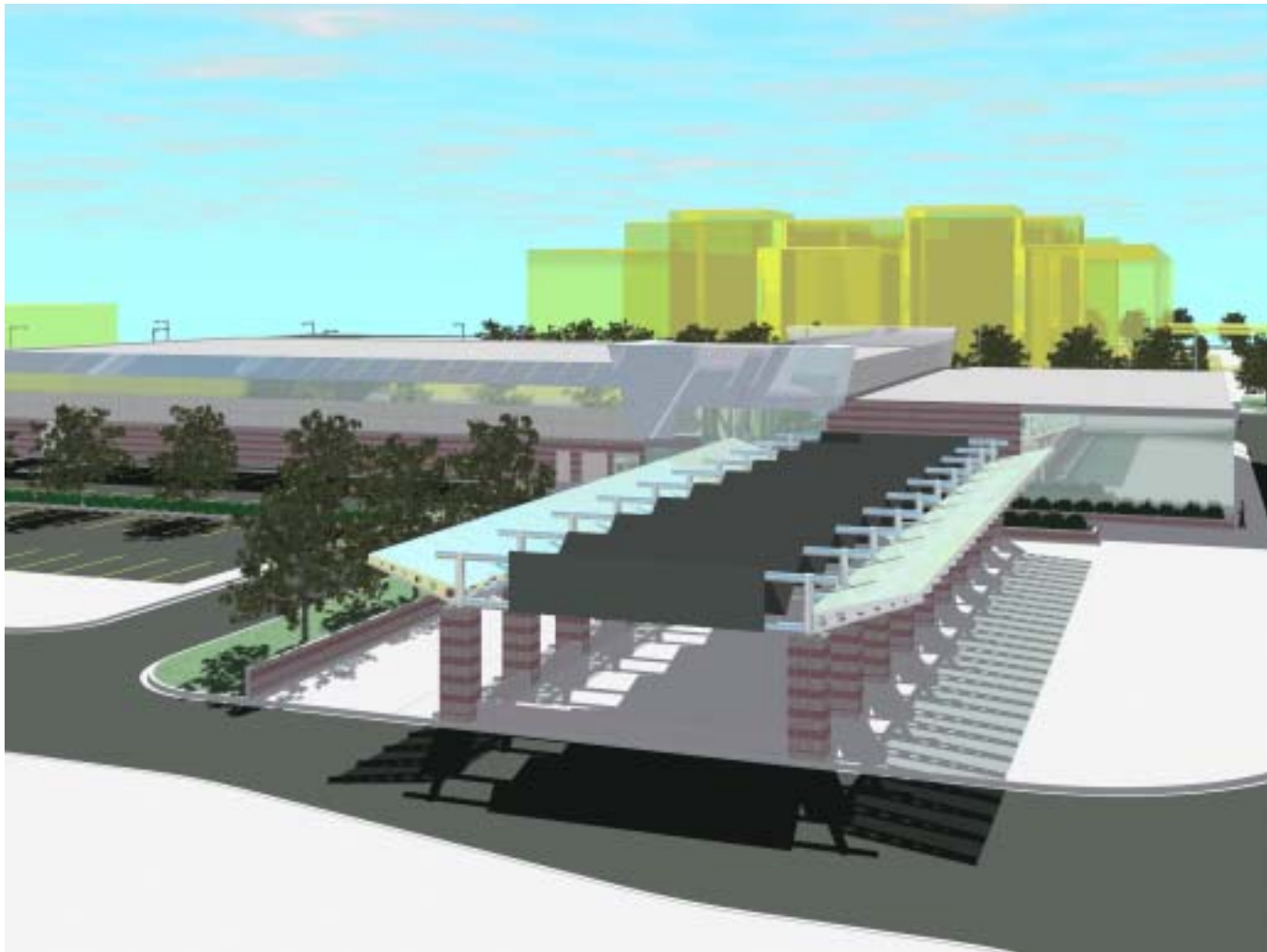
Technical Barriers & Targets - I

- Construction Design:
 - Safety: NO above ground hydrogen / gas piping (requiring innovative construction of “feed” basement -- Class 1, Div 2, Group B classification)
 - Safety: Underground protection for hydrogen conduits (Note: NO existing codes for buried hydrogen lines!)
 - Modular “plug and play” easy interchange of power generators (requiring flexible foundation “feed” interconnections from below)

Technical Barriers & Targets - II

- Operations and Control:
 - Study system stability and system economics from diversity of power sources and fuel feeds
 - Provide for automatic and remote shut-offs and shutdowns (pressure sensors and in-duct hydrogen and gas sensors, and flame detectors)
- Power Pavilion:
 - Ensure all power sources are weather-proofed with in-enclosure sensors

POWER PAVILION



Approach: Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - I

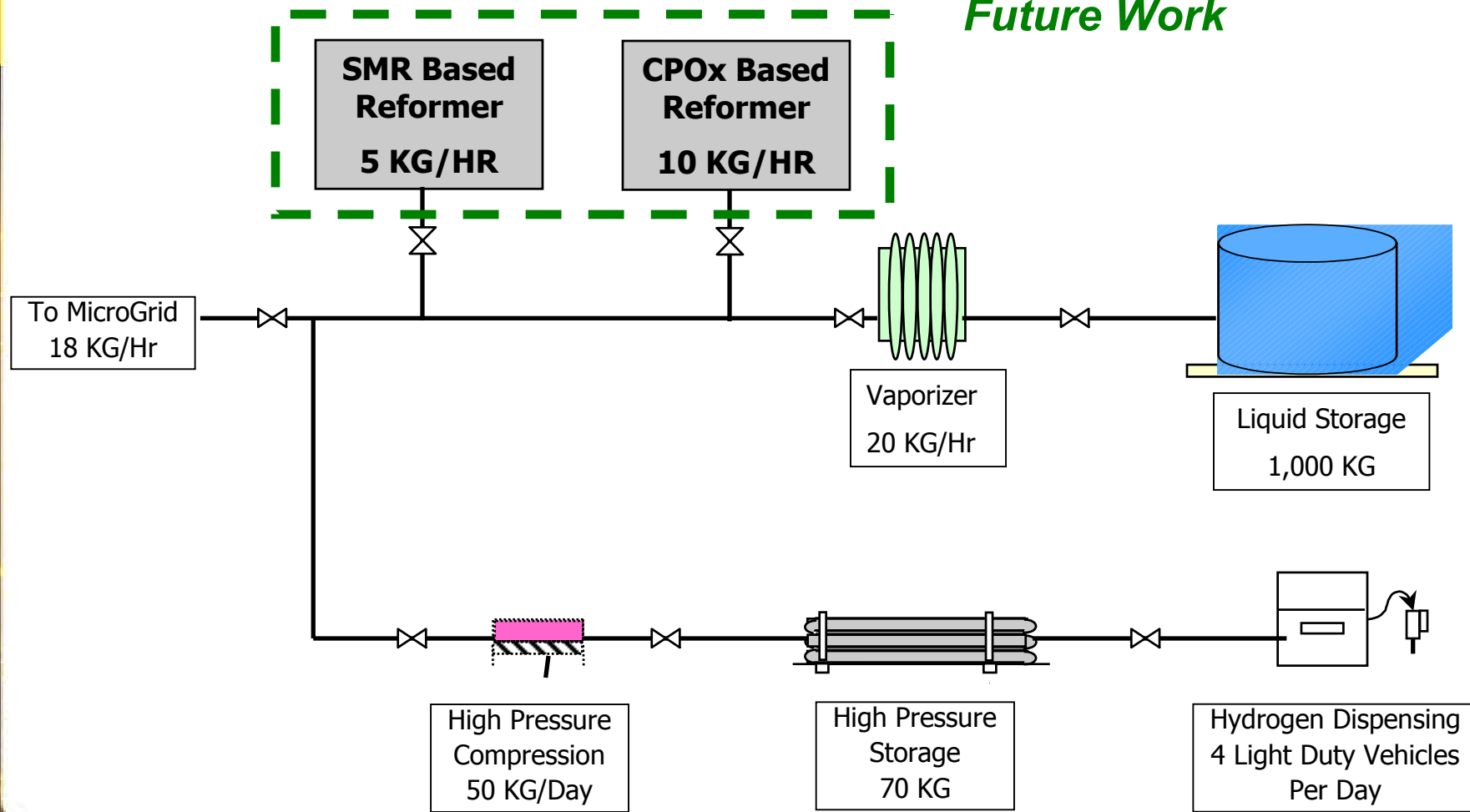
- Determine the overall economics of hydrogen use for power generation in different power technologies; compare the economics for hydrogen as fuel in vehicular applications
- Compare the hydrogen data with data with other fuel feeds: natural gas, bio-fuels, etc. (within the context of power generation in a microgrid)

Approach: Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - II

- Exploit microgrid data to develop high security/reliability power system applications
 - Applications development (e.g. Military, Homeland Sec.)
 - Equipment testing and verification (DG/CHP, ride-through, control/interface gear)
- Utilize hydrogen fueling system for the development of small scale on-site H₂ production technologies
- Leverage laboratory to facilitate system integration/packaging

Hydrogen Supply System

Future Work



Project Safety - I

- **Design & Construction:**
 - **Innovations in below-ground hydrogen lines (follow natural gas line protocols; develop flexible foundation “feed” interconnects)**
 - **Classification of “feed” basement as Class 1, Div. 2, Group B (except for non-classified areas for inverters and other electrical switchgear and Class 1, Div. 1 for the sump pump pit)**

Project Safety - II

- **Operations & Controls:**
 - **Low pressure sensors for automatic shut-downs and in-duct hydrogen and gas sensors and flame detectors**
 - **Provision for remote and automatic shut-downs**
 - **Extensive grounding provisions**
- **Co-ordination with Praxair and with Michigan Dept. of Environmental Quality for liquid hydrogen storage and refueling**

Project Timeline

| | System Design | Start Final Design | Equipment Ordered | Equipment Delivered | Env Permit Obtained | Begin Construction | System Commissioning |
|-------------------|---------------|--------------------|-------------------|---------------------|---------------------|--------------------|----------------------|
| NextEnergy Center | ✓ | ✓ | 05/04 | on-going | N/A | 04/04 | 04/05 |
| Microgrid | ✓ | ✓ | ✓ | 08/04 | 02/04 | 05/04 | 04/05 |
| Hydrogen Systems | ✓ | 05/04 | 06/04 | 08/04 | 04/04 | 07/04 | 04/05 |

Technical Progress

- **System Designs for NextEnergy Center -- all completed**
- **Various Power Sources for Microgrid -- specified and ordered**
- **Final Designs for Center and Microgrid -- accepted (Hydrogen system design to be accepted in May)**
- **Environmental permits obtained**

Interactions & Collaborations

- **DTE Technology: Microgrid Design**
- **Plug Power: 5 kW PEM Fuel Cells (stacks only)**
- **STM: 55 kW Stirlings (H₂ and natural gas fed)**
- **iPower: 85 kW units (based on GM engine)**
- **Stuart Energy: 120 kW Ford H₂ ICE**
- **Praxair: Liquid Hydrogen and Fueling Station**
- **Univ of Michigan: Analysis / computations of emissions and efficiencies based on the microgrid components for power generation**

Power Generators in the NextEnergy Microgrid



Plug Power 5 kW PEMFC (stack portion only; no reformers; no inverter section)



400 kW Walther Turbine

Power Generators in the NextEnergy Microgrid



*STM Stirlings in
outdoor enclosure*



85 kW iPower ICE

Future Work - I

- **Develop the Codes and Standards “Best Practices” database and conduct the annual workshop in cooperation with DOE**
- **Complete and Issue the Teaching Modules and Educational Resources for the “Hydrogen Education Teaching Module”**

Future Work - II

- **Incorporate reformers into hydrogen supply (steam-methane reforming, CPOx – based reformer):**
 - **Post-treatment processes for purity requirements**
- **Explore bio-fuel feeds into Stirling engines (new hot-end designs needed)**
- **Develop innovations in energy storage, load-management to improve microgrid stability and reliability**